ON THE MEANS

OF

PRODUCING AN INTENSE HEAT,

BY THE

COMBUSTION OF OXYGEN,

AND

HYDROGEN GASES.

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Read, Jan. 12, 1818.

ABOUT fifteen years ago, Mr. Hare, an American, described an apparatus for burning a mixture of oxygen and hydrogen gases, but his observations were not much attended to; since that time several refractory metals have been discovered, and it is surprising, that no one thought of using this powerful instrument to accomplish their fusion. Dr. Marcet's spirit lamp blown by oxygen, and even the immense voltaic batteries of Mr. Children, (*a*) are inferior to it for these purposes, and the expence of procuring and using it is but trifling. However, it was neglected till the brilliant researches of Davy, on the combustion of gases, led him

(*a*) Tungsten and Iridium were not perfectly fused in their flame.

to the discovery, that flame cannot pass through capillary tubes, and he had the courage to ignite the most violent of explosive mixtures at the jet of Newman's blow-pipe. All know the wonderful powers of this invention in the hands of Dr. Clarke ; and though his reduction of the earths, which a few years ago would have been inestimable, has not increased our certainty of their metallic nature, without doubt, chemistry is highly indebted to him and he is entitled to great praise for his activity in this investigation. Yet, notwithstanding the beauty of this contrivance, I think that Hare's instrument is better adapted to the uses of the chemist ; it is, perhaps, inferior in power, but this is counter-balanced by great advantages, which it is the object of this communication to indicate, and at the same time to detail some of the facts which I have observed. Mr. Hare's description of his blow-pipe was published in the 14th vol. of Tilloch's Magazine, much of the paper is occupied with an inconvenient sort of gas-holder, but his account of the effects of the *gaseous flame* is very striking, and had he not added iron and plumbago to the subjects of his experiments, he must have anticipated Dr. Clarke. His gases were contained in separate vessels, they were conducted from these by tubes which united in a conical nozzle $\frac{1}{8}$ of an inch long, and the mixed stream was ignited at its aperture. At first sight, it appears that no accident can happen, as the mixture takes place only in the nozzle, but, if we consider more attentively, it may be feared, that an inequality of pressure in either of the gasometers might force its gas into the other: if this takes place in that which holds the oxygen, it must become apparent by the extinction of the flame, and may be guarded against ; but in the case of the hydrogen, we have no such security, as it will burn, while at the same time

it is contaminating the other gas, till the mixture arrives at the exploding point, and destroys, if not the operator, at least the apparatus. This apprehension was increased in me by the recollection of an explosion which endangered one of our most accomplished members: an instrument invented by Cuthbertson, to shew the formation of water during the combustion of hydrogen, in which the flame was fed nearly as in the American blow-pipe, from some event of this kind was shattered with a frightful detonation. Such considerations long restrained me from gratifying the curiosity which Mr. Hare's account excited, till the news-paper accounts of the new blow-pipes added a fresh stimulus. However, I tried the instrument which I constructed after his plan, with air instead of oxygen, and it appeared that my caution was not unnecessary, for an explosion took place in a few minutes, and blew to pieces the connecting tube of the air gasometer, which was in this trial of glass cemented to the stopcock. It soon occurred to me that the possibility of such an event might be prevented by a simple contrivance, of which I lay a drawing before the Academy, and I have not had any reason to distrust its efficacy, though I have, in some instances, maintained the flame for 28 and 30 minutes without intermission. In Fig. 1, the tube A, connected with the oxygen gasometer, is an inverted syphon, its ascending leg rises through the neck of the small glass bell B, into which it is cemented; the shaded part represents mercury, through which the tube passes, being protected from it by cement. C is a smaller bell, from whose summit the tube D conveys the gas to the blow-pipe; In using this, the bend of A, (which is $\frac{1}{8}$ of an inch wide) is filled with water to the height of 4 inches, it is then screwed to its gasometer, the bell C is pressed down

into the mercury, and the blow-pipe screwed to the other gasometer. When we turn the stopcock of the oxygen, the gas drives the water before it into the bell, and rises through it in bubbles as represented in the plate; but were its elasticity overpowered by that of the hydrogen, the water would be driven back into the longer leg of the syphon, and would add to the oxygen a pressure of eight inches, which is more than enough, as the total force of the hydrogen is seldom more, in my apparatus, than six inches. This safety apparatus (*b*) might be applied to the hydrogen, but it is unnecessary, as an excess of oxygen puts out the flame. Fig. 2, represents the nozzle of the blow-pipe as I use it, for that of the inventor did not answer my expectation, except when its aperture was small; when it was $\frac{1}{50}$ of an inch, it became apparent that the gases were not accurately mixed. D and E are the tubes which bring the gases; they are soldered into holes, drilled through the piece of brass F, so that their apertures are at its surface, and their sides in contact, the metal is cut away between them, the piece G applies closely, being fitted by grinding, and it is clear, that the most perfect mixture must take place while the gases pass through it. As this jet is made of brass, it must be kept cooled by any convenient method; I surround it, in general, with moistened lint, but this may be avoided by making it of platina. The widest aperture which I have tried is $\frac{1}{30}$ of an inch, and its performance is most satisfactory.

When the machine is used, the hydrogen cock is opened, and

(*b*) It is scarcely necessary to tell the chemical reader, that this is only a modification of Welter's tube; the mercury allows room for flexion of the parts and latitude of adjustment.

the stream ignited, it gives a different flame, scarcely luminous, but hotter than a candle urged by the blow-pipe, for I have fused by it platina wire of $\frac{1}{150}$ of an inch, and it may be remarked, by this means we can ignite small quantities of precipitates, &c. to whiteness in the most elegant manner on a leaf of platina. Having made the flame of whatever size we judge necessary, we gradually admit oxygen, it changes its appearance, and is impelled with much greater rapidity, diminishing in thickness, and becoming more pointed and dense, while it emits a moaning sound. As the supply of oxygen increases it becomes blue, surrounded by a yellow cone, as in the common blow-pipe; with more oxygen, the yellow cone disappears, and the flame becomes of a brighter blue, it is reduced to a mere thread, and from the deficiency of hydrogen, the brass of the jet burns while the heat is very much diminished. It is not easy to ascertain the proportions of gas which give the greatest heat, nor is it of much use, as a quantity at its maximum is not much affected by a considerable change in the variable on which it depends; but I tried one experiment, to know if it agreed with the theoretic proportion of 2 to 1. When the heat seemed most intense, I extinguished the flame by turning the hydrogen cock, and immediately returned it to its position, I then collected the mixture which issued from the blow-pipe, 1. 5 cubic inches of it were exploded by the electric spark, and after the requisite correction, it was found that there remained 0. 3, therefore 0. 4 of oxygen were present; but my oxygen was impure, containing $\frac{1}{5}$ of nitrogen very nearly, therefore the residue must have contained 0. 1 of this gas, and if the hydrogen was pure, the result gives 10 hydrogen + 4 oxygen + 1 nitrogen, as near as could be expected in this rough mode of estimation to the

true proportion (*c*). It might be possible, by annexing a graduated circle to the keys of the stopcocks, to burn the gases in known proportions, but the eye is able to judge of the heat with sufficient accuracy by the light which is disengaged from the object of experiment. The intensity of this is astonishing; my laboratory, a room of 25 feet square, is strongly illuminated by a globule of platina, not exceeding $_8$ of an inch in diameter, and the phosphorescent glare of some bodies, as lime and magnesia is intolerable, even when the eye is defended by dark green glasses. But what is the origin of this light? we can conceive, that a solid heated in a furnace, when it is surrounded by luminous objects, may receive and emit this emanation at the same instant, but our obscure flame, which is scarcely visible in broad day-light, is incapable of affording it; (*d*) shall we say with Davy, that ordinary matter may become caloric, and light if its particles are put in violent motion, or may we not rather suppose that caloric is under certain circumstances, perhaps by increasing its velocity, convertible into light? Is it too wild an hypothesis, to suppose, that the repulsion by which these ethereal substances are projected from bodies, acts only at insensible distances, and that they are radiated from solids by the united energy of many particles, while in gases, only single atoms can act on them, in consequence of their distance from

(*c*) The heat is much more diminished by an excess of oxygen than of hydrogen, notwithstanding the high capacity of this latter, for it burns in the air, and protects the blue interior flame from the cold medium which surrounds it.

(*d*) If a platina wire be ignited in the unmixed flame of hydrogen, this becomes much brighter, a luminous atmosphere surrounds the metal in a manner which it is not easy to explain.

one another? This would, at least, account for the fact, that gases can scarcely become luminous or lose heat by radiation.

But, to return from such uncertain ground, the purity of the gases must be attended to. I procure my hydrogen from fragments of zinc; the oxygen from peroxide of manganese contains nitrogen, so nearly $\frac{1}{5}$ of its volume whenever I examined it, that I am inclined to suspect it is chemically combined, which is also probable from the circumstance that the water which is contained in the native oxide, and is disengaged during its decomposition, is acidulous with nitric acid. If it be used, it should be carefully dried, as, if it has been exposed to a damp atmosphere, it attracts enough of moisture to produce explosions in the process. I have seen such an accident. Chlorate of potash affords oxygen nearly pure, but its high price precludes its use; red precipitate will be found most convenient and economical; it is easily decomposed in a glazed earthen retort, which will serve repeatedly, and the value of the revived mercury is more than half the price of the oxide. The gas is most impure in the beginning of the distillation; its impurity has been with me from $\frac{1}{75}$ to $\frac{1}{60}$, rejecting the first bubbles. This detail is minute, but it will, I trust, be found useful, as the heat depends materially on the quality of the gas; in fact, in a series of experiments the purity of it should be always stated, and the process of analysis by Volta's Eudiometer is so easy that it may be performed in a few minutes.

I have tried many experiments with this apparatus, and can say that it is a valuable addition to the laboratory; to describe them at length would be useless, as most of them were but repetitions of what others had done. That the earths are re-

duced in many instances I have no doubt, though from want of sufficient experience or dexterity I have not been able to collect their bases. The alkaline earths give the most marked results. A little artificial carbonate of barytes was placed in a cavity scooped in charcoal, and the unmixed flame directed on it with no effect but incandescence; the heat was raised, and the powder fused with violent effervescence, a yellowish green flame streamed from it for a few seconds, and the liquid soaked into the charcoal, or was volatilized in acrid fumes. This constantly occurred, and I found that the earth retained its acid till its fusion, at which instant it must have partly become a hydrate, and partly been reduced; the metal seems to be soluble in hydrogen, to judge from the uniform tinge of the flame, and this is according to the analogy of potassium, manganese, zinc and iron. Chloride of barium was decomposed, even in the unmixed flame of hydrogen, as might have been expected from the strong affinity between that gas and chlorine, but the base was volatilized. The nitrate afforded the same results as the carbonate, and this whether they were gradually heated, or exposed at once to the most intense action of the flame. Lastly, I used the earth itself, obtained by decomposing pure crystals of the nitrate, which in particular had been freed from iron by ammonia. It cannot be freed from this metal by crystallisation, and might easily contain enough of it to afford deceptive appearances in these experiments. (I had found that a mixture of the carbonates of manganese and lime, when reduced in a powerful blast furnace, gave a regulus of which $\frac{1}{4}$ must have been calcium, and by analogy iron and barium might be expected to possess the same relation.) The earth then obtained was gray, without that

yellowish tinge which it generally has, and on essaying it, I found it free from any impurity but a little carbonic acid, and a trace of platina from the crucible. A fragment of it exposed on charcoal to the flame entered into the same watery fusion as the carbonate, and was dissipated with the coloured flame. When it was placed on a fragment of Wedgewood's ware, avoiding the fusion of the support, the appearances were rather different; during the few seconds which elapsed before it acquired the temperature of the flame, some hydrate was formed which melted, but the remainder resisted fusion, and was changed into a sort of frit; this evolved the usual flame, and it was obvious that the reduction was taking place. In this and subsequent experiments, I examined the residue for the metallic lustre, but I never *certainly* found it, and I do not think that any hydrogen was disengaged when these residues were passed into dilute muriatic acid over mercury; some gas was liberated, but I suspect it to have been carbonic acid, as it was totally absorbed by ammoniacal gas when added in excess above what was required to saturate the acid (*e*). I am therefore inclined to think that the barium was volatilized as fast as it was formed.

The various bodies on which I have tried experiments are, with few exceptions, fused in a few minutes, shivers of gunflint melt rapidly into globules, hydrate of alumine is rather more refractory, the subsulphate of it is easily fusible. Magnesia was blown away by the blast, but 4 parts of it with 1 of hydrate of alumine gives a clear glass. Lime is most untractable, the

(*e*) The first specimens of barytes which I obtained gave a gas which was not absorbed by this treatment: I suspect that it was oxygen from peroxide of barium, as they were deprived of this property by the application of a violent heat.

common limestones vitrify with facility, granular white marble crumbled as it lost its acid, and its particles were dispersed, but in some instances I have seen its angles rounded and glazed. The difficulty of fusing it proceeds chiefly from its whiteness, by which much heat is lost.

The metals are fused, and their oxides reduced in every instance which I tried, but unless we operate on large masses the reguli are burnt at the moment of their formation; these decompositions are produced by the excess of hydrogen, and some of the metals which form carburets can be obtained in purity only by this method; for example, manganese and nickel; a fragment of rutilite fused, and the reduced titanium burnt with violence. Oxide of tungsten gave a button, but too small to take its S. G. A piece of manganese was fused, and kept for some time, when an excess of oxygen was admitted it deflagrated violently. A globule of copper was vaporised with a flame of great splendour; gold, silver, and platina are dissipated, not in flame, but by a vehement ebullition which throws their particles to a distance. I lay before the Academy a button of this last metal, weighing 72 grs. which was obtained by fusing on charcoal, 3 globules of it weighing 84 grs. so that no less than 12 grs. were dissipated. This enormous loss arose from the direction of the blowpipe, for altering which I had made no provision, and as platina is a very bad conductor of caloric, that portion of it which was next the flame was boiling before the more remote part was fused. However it was fused in less than three minutes, and remained liquid some time after it was removed from the flame, so that I am confident it might be cast in moulds, and by making four or five of these flames con-

verge on a mass of platina, it might be melted in the quantity of several ounces.

I shall conclude by stating why I prefer this instrument to that of Davy. In the first place it is less expensive; the two gas holders are not to be reckoned as parts of it, they are found in every laboratory, and are, in fact, necessary to the use of the other, and the blowpipe can be afforded for five shillings. Secondly, it does not endanger the operator, while the other is fraught with peril, and even with the improvements which have been made on it, it is, in no little degree, formidable; the gases are mixed in the most explosive proportion, and from their compressed state, the machine may not unaptly be compared to a loaded shell; its insecurity is acknowledged by the gentleman who is most dexterous in the use of it, as he finds it necessary to operate behind a bomb proof.

Thirdly, It affords greater facility in prolonging an operation. With a nozzle of $\frac{1}{30}$. I find that 150 cubic inches of the mixed gas escape in a minute under the pressure of 6 inches; now the instruments of Newman, which I have seen, do not hold more than 80 cubic inches, and without enormous condensation none of them could supply such an aperture for five minutes. Now we cannot enlarge its receiver without augmenting the danger, and the condensation is also limited, for the gases explode by sudden compression, and the syringes now used are too large to be wrought slowly against a high pressure.

Fourthly, the effect is very little inferior, if at all; no advantage is gained by having the gases in a common receptacle, and very little by their condensation. Could the new blowpipe be used with gases, whose elasticity was no more than an inch or two

of water, it would not give more heat than a flame of hydrogen burning in an atmosphere of oxygen, (*f*) and therefore any mixture more than is required for the combustion is unnecessary. The compressed state of the gases is of moreimportance; if while a jet of hydrogen were burning in oxygen their densities were suddenly doubled, all other circumstances remaining the same, the heat would be much increased, for the same quantity of caloric would be evolved in half the space. But the quantity of caloric evolved cannot be the same, for much heat is given out in condensation, and this must be subtracted from the product of combustion. Air suddenly compressed into $\frac{1}{8}$ of its volume is heated upwards of 1000°, how much more we know not; and besides this in the new blowpipe, the condensed gases are in the act of absorbing heat during their ignition, for they are expanding, and the escape of compressed air has been actually proposed as a frigorific process; and if we further consider that all compression is at an end when the gases arrive at the end of the tube, or in fact before they arrive at the body to be heated, we must admit that little augmentation of effect is produced by it.

Lastly, we can vary the properties of the flame at pleasure, while with the new blowpipe the proportions of the gases are invariable during an experiment. If the common blowpipe had not its oxygenating and deoxygenating flame, it would be of comparatively small value to the mineralogist; but our instrument possesses both these powers in the highest degree, and it thus

(*f*) This seems to follow from the fact that hydrogen when burnt with atmospheric air in my blowpipe, and in the open air, had equal powers of fusing platina wire.

enables us, in a single essay, to know the habitudes of a substance with respect to caloric through a wide range of temperature, and to combine with its agency either the affinity of oxygen, or the action of the most powerful reducing body which chemistry affords. We can arrange our flame as the phenomena may direct, and increase the magnitude of this apparatus without limit; while the other cannot, in prudence, be attempted on a large scale, and is scarcely manageable as to the nature and intensity of its flame.

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January 11, 1818.

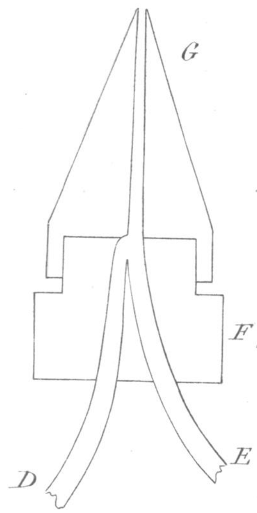

Fig 2

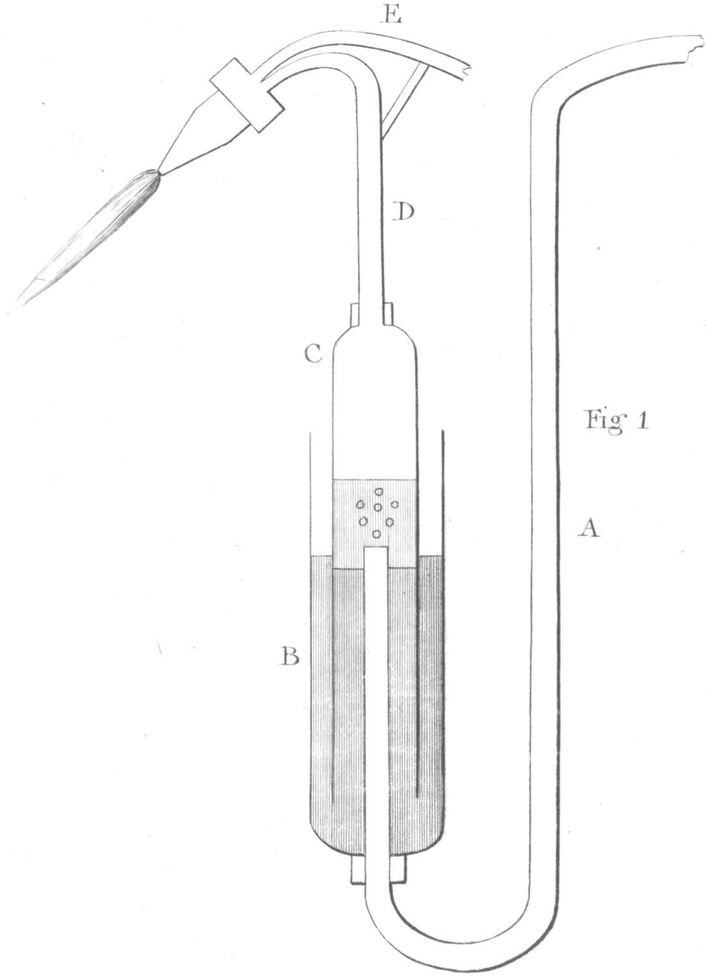

Fig 1